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LISTS OF SPECIES

Anurans of the Reserva Biológica do Parazinho, Municipality of Macapá, state of Amapá, eastern Amazon

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ABSTRACT: We report a list of anurans from the Reserva Biológica do Parazinho (00°52′30″ N, 49°59′15″ W), a strictly protected area, part of the Bailique archipelago, in the municipality of Macapá, state of Amapá, Brazil. The study was carried out in September–October 2010 (dry season) and May–June 2011 (rainy season). We recorded 13 species of anurans, distributed among four families: Bufonidae (1), Hylidae (8), Leptodactylidae (3) and Pipidae (1). The accumulation curves did not stabilize, suggesting that the community was not completely sampled. This study provides the first information on anurans in insular areas of the state of Amapá, and highlights the importance of these areas for the conservation of anurans.

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INTRODUCTION

Brazil has the highest richness of amphibians in the world, represented by 1,026 species (Segalla *et al.* 2014). A substantial portion of the species occurs in the Amazon region, with 232 recorded amphibian species (Ávila-Pires *et al.* 2007). However, these numbers are likely to be underestimated, as many regions of the Brazilian Amazon remain poorly studied or have as yet not been sampled (Bernarde *et al.* 2011, 2013). According to Azevedo-Ramos and Galatti (2001), only 29 localities have been surveyed in the Brazilian Amazon.

Studies on the composition of amphibians in the Brazilian Amazon have been carried out mostly in the states of Amazonas (Lima *et al.* 2006; Ilha and Dixo 2010; Prudente *et al.* 2013), Pará (Ávila-Pires *et al.* 2010; Bernardo *et al.* 2012), Rondônia (Bernarde and Macedo 2008; Piatti *et al.* 2012) and Acre (Bernarde *et al.* 2011, 2013). Located in the northern Amazon Basin, the state of Amapá has approximately 75% of its territory protected by 19 Conservation Units and five Indigenous reserves (Drummond *et al.* 2008).

Herein, we report for the first time a list of anuran species from Reserva Biológica do Parazinho, a fluvial island located in the Amazon River basin. These records aim to fill the knowledge gap in the occurrence and distribution of amphibians in eastern Amazonia.

MATERIALS AND METHODS

The study was carried out in the Reserva Biológica do Parazinho, a strictly protected area (biological reserve, as defined by Brazilian environmental laws; see Rylands and Brandon 2005). Parazinho is a fluvial island and part of the Islands of Bailique in the municipality of Macapá, and the Amazon River Basin, Brazil (Figures 1 and 2).

The vegetation cover consists of *Rhyzophora mangue* L., *Avicennia nitida* Jacq., and *Clitoria arborea* Benth., which form a low forest with an understory. A flat area with clayey, salt marsh, and sandy sediments of mixed origin, fluvial and marine, characterizes the relief. Since the humidity is a constant influence of the Amazon River and the Atlantic Ocean, the area exhibits marine characteristics with the formation of sandbanks, subjected to periodic flooding and constant sediment deposition (Drummond *et al.* 2008).

In this study, 4- to 7-day field trips were carried out between September and October 2010 (dry season) and May and June 2011 (rainy season), totaling 28 days. Observations began at sunset and ended when anuran activity decreased. Anurans were sampled using visual and acoustic survey methods (*cf.* Crump and Scott 1994; Heyer *et al.* 1994). Visual and acoustic searches consisted of slowly walking trails (four trails of 200 m). On each side of the trail, an area of five meters was sampled up to a height of 3–4 m. We searched the leaf litter, decomposing trees, tree holes, vegetation, burrows, and other sites suitable for sheltering anurans. Six hours of searching were conducted on each trail per month, totaling 64 h of observations.

To analyze anuran species richness, rarefaction curves were generated, based on the number of individuals and number of samples, using the program EstimateS 9.1, with 1,000 randomizations (Gotelli and Colwell 2011). Species richness among physiognomies was also compared with the richness estimators Chao 1, Chao 2, Jacknife 1, Jacknife 2, and Bootstrap using the program EstimateS 9.1 (Colwell 2013).

Climate rainfall variables were also obtained from the Nucleus of Hydrometeorology and Renewable Energy of the Institute of Scientific and Technological Research of the state of Amapá (NHMET/IEPA/AMAPÁ).

Specimens were identified based on specialized literature (*e.g.,* Lescure and Marty 2001; Lima *et al.* 2006; AmphibiaWeb 2011; Ouboter and Jairam 2012). Voucher specimens were collected, anesthetized with 5% lidocaine, fixed with 10% formalin and preserved in 70% ethanol. Voucher specimens were deposited at the Herpetological collection of the Federal University of Amapá, Macapá, state of Amapá, Brazil. Collection permits were provided by the Amapá State Institute of the Environment. Voucher numbers are listed in Appendix 1.

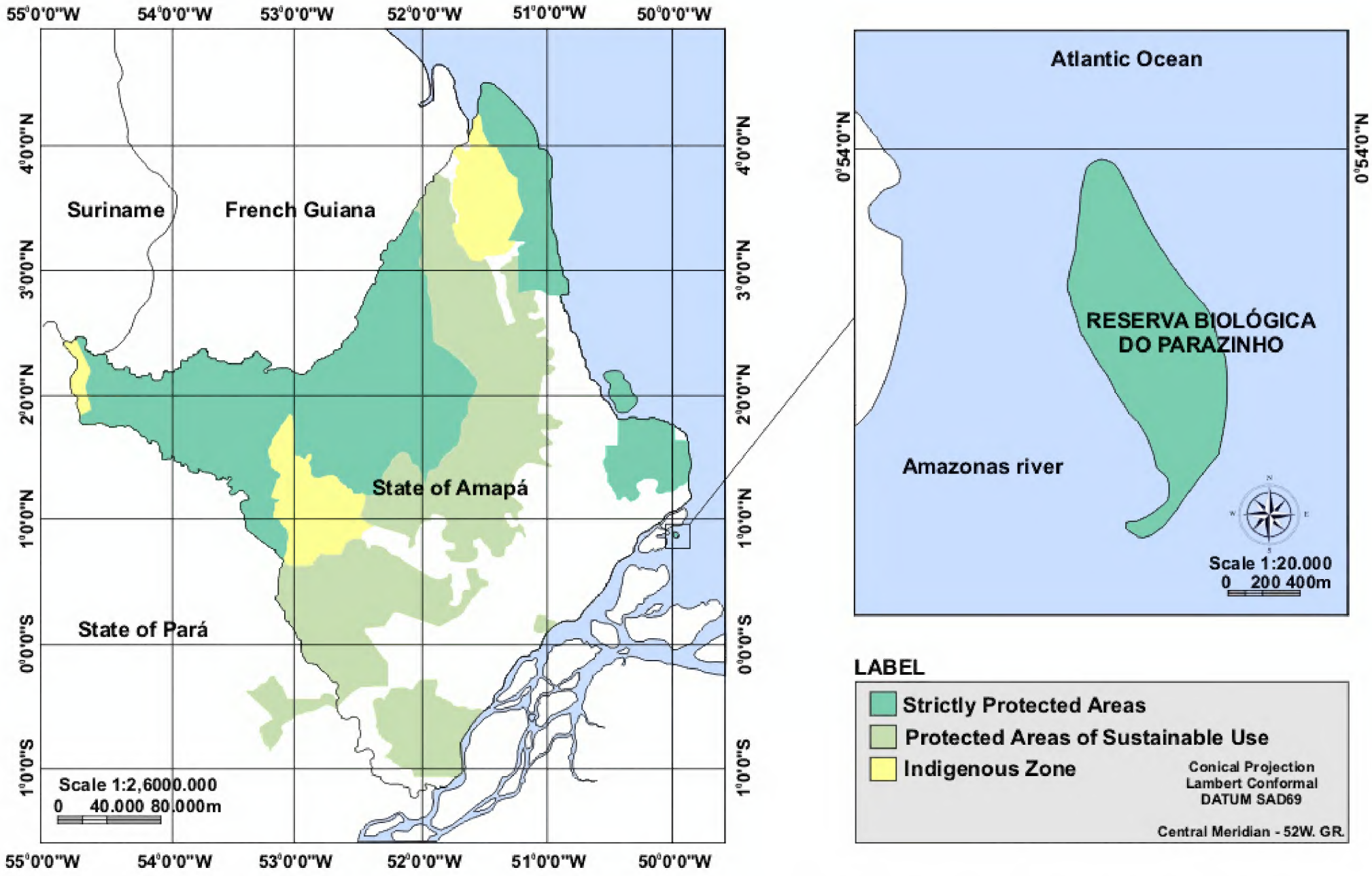

FIGURE 1. Study area showing the Reserva Biológica do Parazinho, state of Amapá, eastern Amazonia, Brazil, after Drummond *et al.* (2008).

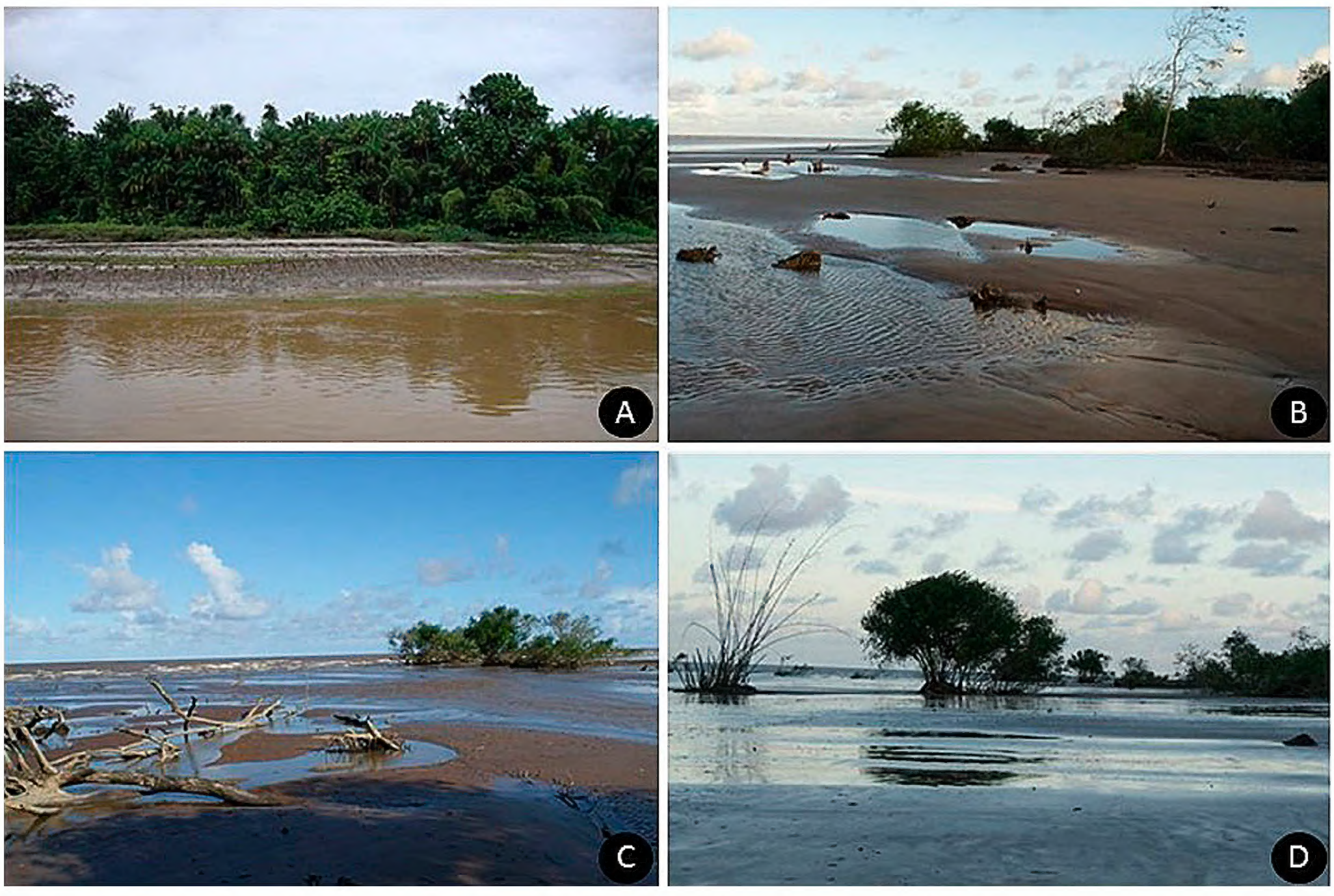

FIGURE 2. Breeding habitats used by anurans on the Reserva Biológica do Parazinho, state of Amapá, Brazil: (A) permanent pond in low forest; (B) temporary pond in sandbanks; (C) temporary pond in flat area; (D) flat area during low tide.

Figure 3. Anurans species found in the Reserva Biológica do Parazinho, state of Amapá, Brazil. (A) *Rhinella marina*; (B) *Hypsiboas boans*; (C) *Hypsiboas raniceps*; (D) *Osteocephalus oophagus*; (E) *Osteocephalus taurinus*; (F) *Pseudis laevis*; (G) *Pseudis paradoxa*; (H) *Scinax ruber*; (I) *Trachycephalus typhonius*; (J) *Leptodactylus petersii*; (K) *Leptodactylus podicipinus*; (L) *Leptodactylus* gr. *latrans*; (M) *Pipa pipa*.

Results

We recorded 189 individuals distributed among four families and 13 species. The most representative family was Hylidae with eight species, followed by Leptodactylidae with three species, and Bufonidae and Pipidae with one species each (Table 1; Figure 3).

The accumulation curves did not stabilize, suggesting that the community was not completely sampled (Figure 4). The most abundant species was *Osteocephalus taurinus* (*n*=30). The least abundant species was *Pipa pipa* (*n*=4) (Figure 5). Abundance was higher in the rainy season (May to June) than in the dry season (September and October) (Figure 6).

Discussion

Species accumulation curves have been widely used to make inferences and evaluate the sampling effort in studies of anuran communities (Armstrong and Conte 2010; Zina *et al.* 2012). The richness indices observed for the study sites were higher in continental areas (*e.g.,* Amazon region). This result is very common in studies comparing islands and continents and agrees with the theory of island biogeography proposed by MacArthur and Wilson (2001) and Silva *et al.* (2008). These differences in species richness may result from the way the islands were formed and the habitats that are available for the establishment and/or maintenance of a given population (Santos *et al*. 2004).

Despite differences in sampling efforts, environmental conditions and size of sampled areas when comparing this study with others in the Amazon region (*e.g.*, 54 spp. in the Urucu Petrol Base, municipality of Coari, state of Amazonas *sensu* Prudente *et al.* 2013; 50 spp. in the forest of Lower Moa River, Cruzeiro do Sul, state of Acre *sensu* Bernarde *et al.* 2013; 23 spp. in municipality of Rio Preto da Eva, east of Manaus *sensu* Ilha and Dixo 2010), the richness of 13 species of anurans recorded in this study is underestimated, as the collector curve did not reach the asymptote and the highest values recorded for the other Amazonian localities range between 23 and 54 species. In addition, further studies on Amazonian communities and anurans with larger sample size and effort and longer duration are needed (Bernarde *et al.* 2011).

In the present study, Hylidae and Leptodactylidae were the families with the greatest number of species, similar to that reported in other studies and following the pattern found in Neotropical environments (Duellman and Trueb 1994; Ávila-Pires *et al.* 2010). For example, in

Table 1. List of anurans species registered in the Reserva Biológica do Parazinho, state of Amapá, Brazil.

FAMILY/SPECIES	N
Bufonidae	
Rhinella marina (Linnaeus, 1758)	15
Hylidae	
Hypsiboas boans (Linnaeus, 1758)	29
Hypsiboas raniceps (Günther, 1859 "1858")	12
Osteocephalus taurinus Steindachner, 1862	30
Osteocephalus oophagus Jungfer & Schiesari, 1995	28
Pseudis laevis Parker, 1935	1
Pseudis paradoxa (Linnaeus, 1758)	13
Scinax ruber (Laurenti, 1768)	17
Trachycephalus typhonius (Linnaeus, 1758)	27
Leptodactylidae	
Leptodactylus petersii (Steindachner, 1864)	1
Leptodactylus podicipinus (Cope, 1862)	6
Leptodactylus gr. *latrans* (Steffen, 1815)	6
Pipidae	
Pipa pipa (Linnaeus, 1758)	4

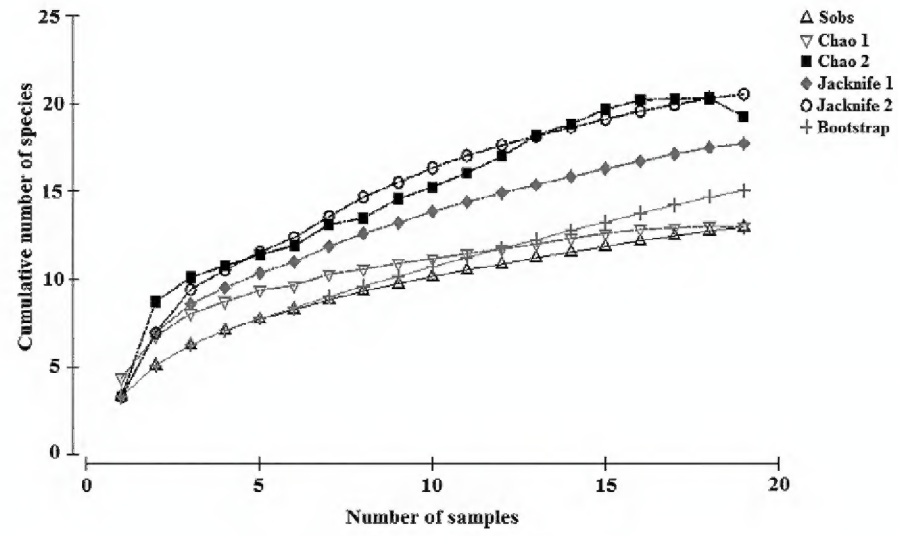

Figure 4. Accumulated curve of anurans in the Reserva Biológica do Parazinho, state of Amapá, Brazil.

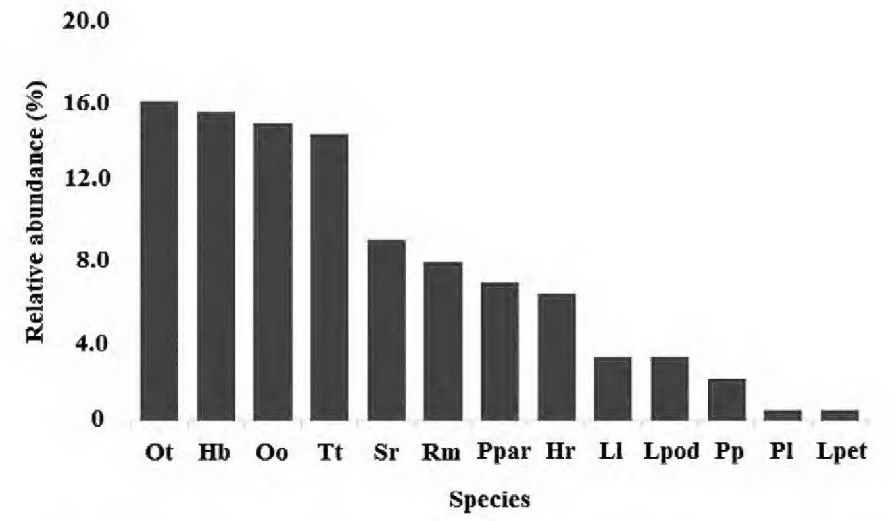

Figure 5. Relative abundance of anurans in the Reserva Biológica do Parazinho, state of Amapá: Ot (*Osteocephalus taurinus*), Hb (*Hypsiboas boans*), Oo (*Osteocephalus oophagus*), Tt (*Trachycephalus thyphonius*), Sr (*Scinax ruber*), Rm (*Rhinella marina*), Ppar (*Pseudis paradoxa*), Hr (*Hypsiboas raniceps*), Lpod (*Leptodactylus podicipinus*), Ll (*Leptodactylus* gr. *latrans*), Pp (*Pipa pipa*), Pl (*Pseudis laevis*) e Lpet (*Leptodactylus petersii*).

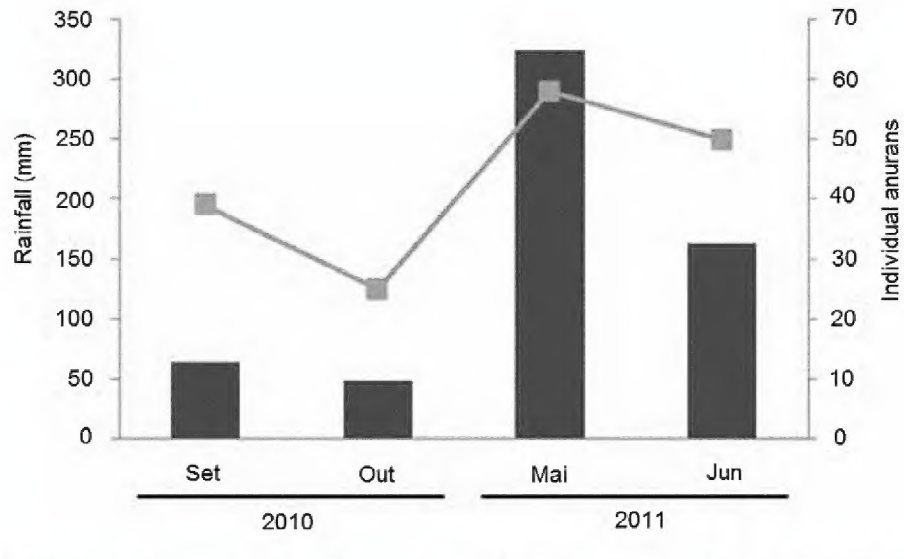

Figure 6. Relative abundance of anurans species registered in in the Reserva Biológica do Parazinho, state of Amapá, Brazil and rainfall accumulation (mm).

the Reserva Biológica do Parazinho, the larger number of hylid species was partly due to the presence of temporary ponds that provided suitable conditions for breeding. All species registered are widely distributed in the Amazon Basin and surrounding areas, such as *Rhinella marina* and *Scinax ruber* (IUCN 2013).

Abundance was higher in the rainy season than in the dry season, which is associated to the permeable skin of anurans and their strong dependence on humidity, mild air temperatures, and rainfall for reproduction (Duellman and Trueb 1994; Santos *et al.* 2007). For anurans, differences observed in species composition and abundance in different environments can be strongly correlated with variations in microhabitat availability, including those suitable for reproduction (Pombal Jr. and Haddad 2007; Araújo *et al.* 2013), hydric resources (Gambale *et al.* 2014), temperature (Haddad and Prado 2005; Saenz *et al.* 2006), vegetation structural complexity (Souza *et al.* 2008) and edaphic factors (Menin *et al.* 2007).

This study provides the first record of the amphibians of the Reserva Biológica do Parazinho. Because it is an island, richness indices were low when compared to studies on the mainland conducted by Queiroz *et al.* (2011) and Pereira-Júnior *et al.* (2013) in the state of Amapá. These authors reported 40 species of anurans in the Cajari Extractive Reserve and 20 species in the University of Amapá campus, respectively. The inventory presented in this article is a contribution to the understanding of the distribution of Eastern Amazon insular anurans, and therefore to their conservation (Azevedo-Ramos and Galatti 2002).

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Appendix 1. Voucher specimens.

Rhinella marina: Macapá: Parazinho (CECCAMPOS 00668); *Hypsiboas boans:* Macapá: Parazinho (CECCAMPOS 00819); *Hypsiboas raniceps:* Macapá: Parazinho (CECCAMPOS 00059); *Osteocephalus taurinus:* Macapá: Parazinho (CECCAMPOS 00079); *Osteocephalus oophagus:* Macapá: Parazinho (CECCAMPOS 00334); *Pseudis laevis:* Macapá: Parazinho (CECCAMPOS 00066); *Pseudis paradoxa:* Macapá: Parazinho (CECCAMPOS 00073); *Scinax ruber:* Macapá: Parazinho (CECCAMPOS 00084); *Trachycephalus typhonius:* Macapá: Parazinho (CECCAMPOS 00584); *Leptodactylus petersii:* Macapá: Parazinho (CECCAMPOS 00782); *Leptodactylus podicipinus:* Macapá: Parazinho (CECCAMPOS 00065); *Leptodactylus* gr. *latrans:* Macapá: Parazinho (CECCAMPOS 00070); *Pipa pipa:* Macapá: Parazinho (CECCAMPOS 00934).